turbulence phenomenon is important for the understanding of dynamic processes in the atmosphere, such as the behavior of buoyant plumes within cirrus clouds, diffusions of chemical species within wake vortices generated by jet aircraft, and microphysical processes in breaking gravity waves. Accurate temperature and pressure data are needed to evaluate chemical reaction rates and to determine accurate mixing ratios. Accurate wind-field data establish a detailed relationship between the various constituents, and the measured wind also verifies numerical models used to evaluate air-mass origin. Since the MMS provides quality information on atmospheric state variables, MMS data have been extensively used by many investigators to process and interpret the in situ data from various instruments aboard the same aircraft.

In FY00, the MMS instrument for the ER-2 successfully completed the Stratospheric Aerosol and Gas Experiment (SAGE)-III Ozone Loss and Validation Experiment (SOLVE) deployed to Kiruna, Sweden. The instrument team produced accurate basic atmospheric state variables that contribute to a broad spectrum of research and investigations. The thermodynamic data provided important measurement constraint and validation for the microphysical studies of the polar stratospheric cloud particles, a critical link in the chlorine activation leading to the destruction of ozone. These basic state data also regulated directly and indirectly the heterogeneous chemical reactions. The 3-D wind data not only provided the meteorological coordinate of the polar vortex, the data supplied the precision for the investigation of mesoscale temperature perturbations that result from mountain waves. In addition, the MMS accurate geometric altitude registration using differential global positioning system (GPS) (less than 5 meter) coordinates provided a significant breakthrough in the interpretation and comparison with satellite-derived data.

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Open Path Diode Laser Hygrometer (DLH) Instrument for Tropospheric and Stratospheric Water Vapor Studies

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The diode laser hygrometer (DLH), developed by NASA's Langley and Ames Research Centers, has flown on the NASA DC-8 on several field missions including Subsonic Aircraft: Cloud and Contrail Effects Special Study (SUCCESS), Vortex Ozone Transport Experiment (VOTE), Tropical Ozone Transport Experiment (TOTE), Subsonic Assessment (SASS) Ozone and Nitrogen Oxide Experiment (SONEX), Pacific Exploratory Mission-Tropics A and B (PEM-Tropics A and B), and the recently completed SAGE III Ozone Loss and Validation Experiment (SOLVE) campaign of 1999-2000. The optical layout of this sensor consists of the compact laser transceiver mounted to a DC-8 window port and a sheet of retro-reflecting "road sign" material applied to the DC-8 engine enclosure that completes the optical path. The advantages of this sensor approach include compactness, simple installation, fast response time (50 millisec (msec)), no wall or inlet effects, and wide dynamic measurement range (several orders of magnitude).

Using differential absorption detection techniques similar to those described in the literature, gas-phase water ($H_2O(v)$) is sensed along a 28.5 meter (m) external path. For dry conditions (generally altitudes above 6 kilometers (km)), the diode laser wavelength is locked onto a strong, isolated line at 7139.1 centimeters (cm),$^{-1}$ while for altitudes typically below 6 km the laser wavelength is locked onto a weaker line at 7133.9 cm^{-1}. By normalizing the laser differential absorption signal with the laser power signal, the $H_2O(v)$ measurement is unaffected by clouds, haze, plumes, etc., thereby enabling high spatial resolution measurements in and around clouds. The $H_2O(v)$ mixing ratio is computed by an algorithm from the differential absorption magnitude, ambient pressure and temperature, and coefficients derived from laboratory calibration of the sensor. These calibrations are conducted prior to each field mission, and they involve measuring the sensor response to known $H_2O(v)$ concentrations flowing through a 3 meter-long chamber at pressures ranging from 100 to 1000 hecto Pascals. Glen Sachse, NASA Langley Research Center, collaborated with the investigator on this study.

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The Argus Instrument

Max Loewenstein, Hansjürg Jost, James Podolske, Jeff Greenblatt

The Argus instrument is a lightweight, infrared (3- to 5-micrometer wavelength) diode-laser spectrometer. It was designed for measuring the atmospheric nitrous oxide (N_2O) and methane (CH_4) tracer fields in situ from balloons and aircraft. The instrument can return atmospheric measurements over the altitude range of 5 to 30 kilometers (km).

In preparation for the winter 1999-2000 SAGE III Ozone Loss and Validation Experiment/ Third European Stratospheric Experiment On Ozone (SOLVE/THESEO 2000) Arctic ozone campaign, Argus was integrated on the ER-2 high-altitude research aircraft during the summer and fall of 1999. Thermal calculations and engineering modifications of Argus were undertaken at Dryden Flight Research Center (DFRC), home of the ER-2, for the successful completion of this task, which also required several test flights to tune up the thermal conditioning system of the instrument. Several Argus improvements were also made to enhance data quality for this mission. These included installing a longer optical-path gas sampling cell, improving laser temperature control, streaming the data analysis code, and adding an in-flight gas calibration system.

The ER-2 component of the SOLVE/THESEO 2000 Arctic ozone study began in January of 2000 with ferry flights from DFRC through Westover Air Force Base, Massachusetts, and then to Kiruna, Sweden, at 67° N. In 12 flights originating in Kiruna, from January through March of 2000, regions both inside and outside the winter polar vortex were sampled by the instruments onboard the ER-2. The research was supported by additional aircraft-, balloon- and ground-based instruments from both the NASA SOLVE and European THESEO elements of the field campaign. The overall purpose of the campaign was to achieve a detailed understanding of the chemistry and the spatial extent and intensity of ozone loss inside the winter polar vortex. Polar Stratospheric Clouds (PSCs) that form during the cold Arctic polar night in the lower (10 to 20 kilometers (km)) stratosphere greatly enhance destruction of ozone by human-caused emissions of chlorine and bromine. The presence of these PSCs is fundamental to the formation of the well-known Antarctic ozone hole, though the amount of Arctic ozone destruction is not as great as that observed annually in the early austral spring over the Antarctic.